

2020 Imaging Guidelines for Thyroid Nodules and Differentiated Thyroid Cancer: Korean Society of Thyroid Radiology.

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Authors: Department of Radiology, Seoul National University Hospital, Seoul National University College of Medicine, Seoul, Korea.

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380429 840 860 04 5 2020 24 8 2020 14 10 2020 01 05 2021 06 05 2021 08 08 2024 Copyright © 2021 The Korean Society of Radiology 2021 The Korean Society of Radiology
<https://creativecommons.org/licenses/by-nc/4.0/> This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited. Imaging plays a key role in the diagnosis and characterization of thyroid diseases, and the information provided by imaging studies is essential for management planning. A referral guideline for imaging studies may help physicians make reasonable decisions and minimize the number of unnecessary examinations. The Korean Society of Thyroid Radiology (KSThR) developed imaging guidelines for thyroid nodules and differentiated thyroid cancer using an adaptation process through a collaboration between the National Evidence-based Healthcare Collaborating Agency and the working group of KSThR, which is composed of radiologists specializing in thyroid imaging. When evidence is either insufficient or equivocal, expert opinion may supplement the available evidence for recommending imaging. Therefore, we suggest rating the appropriateness of imaging for specific clinical situations in this guideline.

Thyroid nodules are a common finding in clinical practice. Approximately 5–15% of thyroid nodules are malignant [1], and the incidence of thyroid cancer is increasing due to various factors.

Various imaging techniques and procedures have been developed for the differential diagnosis of thyroid nodules. These imaging techniques include ultrasonography (US), computed tomography (CT), and magnetic resonance imaging (MRI). When a biopsy reveals thyroid cancer, imaging plays several roles according to the histologic subtype of the malignancy. Differentiated thyroid carcinoma (DTC) arising from thyroid follicular epithelial cells accounts for the majority of thyroid cancers. Papillary cancer accounts for approximately 85% of DTC cases, while follicular cancers account for approximately 12% [2]. In DTC, imaging plays an important role in preoperative staging, operative planning, and surveillance after treatment and in cases of suspected recurrence.

In the 1990s, the American College of Radiology (ACR) recognized the need to define national guidelines for the use of imaging technologies to assist physicians in making decisions. These guidelines are known as the ACR appropriateness criteria (ACR AC). A few studies have been published, including those on the management of incidental thyroid nodules detected on imaging [3] and the ACR AC for thyroid diseases [4].

The number of imaging procedures performed in Korea is estimated to be high, given the country's size and population [5]. However, this number may even be underestimated because many privately-funded examinations are not included [6]. Due to the highly commercial nature of these privately-funded examinations, quality control is required to prevent abuse. In Korea, the rate of imaging of the thyroid is predicted to increase because of its technological progress and the expansion of the insurance system. In the field of radiology, imaging examinations should abide by the principle of justification to protect patients from medical radiation exposure. According to this principle, the benefits must outweigh the potential harm in all circumstances in which patients are exposed, and clinicians should perform only necessary examinations. Apart from the specific medical situation of Korea, it is crucial to define generalizable indications for thyroid imaging to facilitate improvements in effective patient care. The development committee of the Korean Society of Thyroid Radiology (KSThR) has arrived at a consensus that a generalizable and precise AC is currently lacking and that there is a need for comprehensive AC guidelines from various international societies that could also provide detailed recommendations to maximize effectiveness in individual imaging examinations. Therefore, the purpose of this work is to provide a current and comprehensive evidence-based clinical guideline for the evaluation of thyroid nodules and DTC in specific clinical situations.

The guidelines were developed through a collaboration between the KSThR and the National Evidence-based Healthcare Collaborating Agency (NECA) [7]. The scope of the guidelines is presented in Table 1 .

The KSThR has made efforts to provide scientific evidence for the imaging-based management of nodular thyroid disease and thyroid cancers. The KSThR has published clinical guidelines for diagnostic imaging and interventional management of thyroid nodules since 2011, including US diagnosis and imaging-based management [8 9], fine-needle aspiration (FNA) [10], core needle biopsy [11 12], radiofrequency [13 14], and ethanol ablation therapy [15]. The NECA is a national agency that provides evidence-based information about medical devices, medicines, and health technology obtained through objective and reliable analyses. The KSThR launched a committee comprising 15 members appointed by the KSThR and the NECA to develop clinical practice guidelines for thyroid nodules and DTC. The committee included medical imaging specialists, research methodology specialists, and clinical guideline specialists to coordinate the overall planning and research methodology. The committee established an adaptation methodology for Korean clinical imaging guidelines (K-CIG) for guideline development [7]. The methodology, identifying information, and availability are summarized in Tables 2 and 3 .

Clinical situations selected by the working group were reviewed by the development committee and a consensus group composed of clinical experts. Four clinical situations were identified.

1) Evaluation of known or suspected thyroid nodules, initial imaging.

The relative radiation level (RRL) in the ACR AC was established according to the effective dose measured in mSv. The final RRL used in the K-CIG was determined after reviewing the ACR AC, as well as the recent literature and irradiation dose study results from Korea. Imaging examinations and radiation doses are indicated using symbols, which are described in the K-CIG (Supplementary Table 1) [7].

A systematic search for previously-established guidelines was performed using international databases published up to October 2019, including Ovid-MEDLINE, Ovid-EMBASE, and National Guideline Clearinghouse, as well as major domestic databases.

After identifying previously-established guidelines addressing clinical situations 1, 2, 3, and 4, guideline selection was performed independently based on predefined inclusion/exclusion criteria. After excluding duplicates, screening titles, and abstracts, the full texts of the remaining articles were read, and eight, nine, seven, and seven articles were selected for clinical situations 1, 2, 3, and 4, respectively (Figs. 1 , 2 , 3).

Quality appraisal of the selected guidelines was performed by two members of the development committee (with 7 years of experience in thyroid imaging, and an expert in clinical guideline development) using the Korean Appraisal of Guidelines for Research and Evaluation II tool [16]. Guidelines with a score of < 50 in the “Rigour of Development” domain were not recommended by the development committee.

Domestic guidelines that were developed by experts were selected despite a low score [7]. Eight, seven, five, and five guidelines were finally selected for clinical situations 1, 2, 3, and 4, respectively.

The members of the development committee reviewed the literature supporting the recommendations of the selected guidelines. The level of evidence of each literature citation was graded according to the evidence level criteria of the K-CIG [7]. The details of the level of evidence grading and assessment of recommendations are described in Table 4 . The evidence used is summarized in Supplementary Table 2 .

The concept of appropriateness, as applied to health care, balances the risks and benefits of a treatment, test, or procedure in the context of available resources for an individual patient with specific characteristics (Table 5) [17].

After a discussion and comparison of the recommendations and the evidence in the literature for the selected guidelines, draft recommendations were prepared by the guideline committee. Quality of evidence, clinical benefits and harms, acceptability and applicability, and radiation dose were used for the drafting of guidelines using the methodology described in the RAND Corporation/University of California Los Angeles Appropriateness Method User Manual [18].

Panels composed of experts in thyroid radiology and methodology reviewed the evidence and discussed the recommendations. For each clinical situation, feedback and suggestions for revisions were obtained from panel members via e-mail and face-to-face meetings. All suggestions were regularly reviewed by all panel members through tracked changes and online meetings. The drafted document was revised until no further revisions were requested by any panel member. Thus, a general consensus was reached regarding the recommendations and the manuscript. The evidence level and net benefits were the main factors determining the recommendations. Appropriateness was discussed further to consider the clinical applicability of the guidelines and their impact on patient outcomes. After a draft of the guidelines was finalized, an internal peer review was performed by members of the KSThR. The draft was made available for a month on the KSThR website (<http://www.thyroidimaging.kr>). For clinical situations and imaging modalities with a low level of evidence, the recommendations were often based on expert opinion.

1. Neck US is usually appropriate for the evaluation of suspected thyroid nodules.
2. Neck US with US-guided biopsy of thyroid nodules is usually appropriate for the evaluation of thyroid nodules.
3. Neck CT or MRI with or without intravenous (IV) contrast is usually not appropriate for initial imaging of known or suspected thyroid nodules. Neck CT or MRI with IV contrast can be additionally performed when a nodule is suspicious for intrathoracic extension or advanced thyroid cancer.

For patients with clinically-suspected thyroid nodules, imaging should be performed to determine the origin of the mass and to evaluate associated changes in the thyroid gland and neck. After reviewing the guidelines for the diagnosis and treatment of thyroid nodules, the final eight guidelines were selected for clinical situation 1 [2 4 19 20 21 22 23]. Table 6 shows the recommendation matrix of the existing guidelines for clinical situation 1.

The eight guidelines recommend neck US as a primary diagnostic modality when a thyroid nodule is suspected [2 4 19 20 21 22 23]. US is a highly sensitive method for the detection of thyroid nodules and can be used to determine the size and morphological features of the nodule, to determine nodal involvement [24 25 26 27 28 29], and to determine the need for FNA [30 31]. Morphologic features and nodule size were used to guide the decision to perform biopsy under various risk stratification criteria [9 19 21 23 32 33]. US-guided biopsy or follow-up should be performed according to the findings of initial US scans together with other clinical and laboratory findings [27].

There is insufficient evidence supporting the ability of CT and MRI to differentiate thyroid cancers from benign nodules unless there is evidence of either local tumor invasion or metastasis [3 34]; however, these methods may be helpful for determining the extent of goiter with intrathoracic or retropharyngeal extension. They may be used as additional modalities if there is a suspicion of advanced thyroid cancer (aerodigestive tract or recurrent laryngeal nerve invasion, lymph node [LN] metastasis) [4 19 23]. In patients with advanced disease, IV contrast agents should be administered to optimize imaging. CT can define the degree of tracheal compression more effectively than US. Although MRI is an alternative to CT, CT is preferred because it is associated with a lower risk of respiratory motion artifacts, shorter scan time, and a higher resolution. Therefore, CT is more effective for evaluating LNs in the entire neck. However, the preferred

modality for a suspected thyroid nodule is US [35].

1. Neck US is usually appropriate for the preoperative evaluation of DTC.
2. US-guided biopsy and/or washout thyroglobulin (Tg) for neck LNs are usually appropriate for the preoperative evaluation of DTC.
3. Neck CT or MRI with IV contrast may be appropriate as an adjunct to US for the preoperative evaluation of DTC with clinical suspicion of advanced disease.
4. Chest CT with IV contrast may be appropriate to evaluate the lung parenchyma or the mediastinum in patients with clinical suspicion of advanced disease.

The basic goals of initial therapy for patients with DTC are to remove the primary tumor, treat the disease that has extended beyond the thyroid capsule, and treat clinically significant LN metastases [21]. The completeness of surgical resection is an important determinant of the outcome, whereas residual metastatic LNs represent the most common site of persistent disease or recurrence [36 37 38]. Preoperative staging and the risk of recurrence determine the need for radioiodine ablation (RAI) therapy after thyroidectomy, as well as the protocol for postoperative surveillance [21]. Therefore, accurate preoperative staging is important for surgical planning and predicting tumor recurrence. After reviewing the guidelines for the diagnosis and treatment of thyroid nodules, seven guidelines were selected for clinical situation 2 [2 4 9 19 21 23 39 40]. Table 7 shows the recommendation matrix of the existing guidelines for clinical situation 2.

The seven guidelines recommended neck US for the preoperative evaluation of DTC [2 4 9 19 21 23 39]. Preoperative US should be performed in patients with thyroid cancer to evaluate the site and size of the primary tumor, contralateral lobe, gross extrathyroidal extension (ETE), and LN metastasis in the neck [23 41 42 43 44 45 46 47 48 49]. US is accurate for predicting ETE and detecting cancer in the contralateral lobe [47 50 51 52 53 54 55 56]. US has excellent resolution and shows good diagnostic accuracy for detecting cervical LN metastasis [42 43 44 45 46 47 48 49], especially for LNs in the lateral neck [57]. US-guided biopsy should be performed to confirm malignancy in suspicious cervical LNs (≥ 3 –5 mm) and indeterminate LNs (> 5 mm; short diameter) detected by US in cases in which biopsy may change the surgical management [9]. The addition of FNA-Tg washout to the evaluation of cervical LNs might be appropriate in selected patients; however, the interpretation of the results may be difficult in patients with intact thyroid glands [58 59 60 61 62 63 64 65].

Seven guidelines recommend the preoperative use of cross-sectional imaging studies of the neck (CT or MRI) with IV contrast as an adjunct to US in cases with clinical suspicion of advanced disease, including invasive primary tumors or clinically apparent multiple bulky LNs [2 4 9 19 21 23 39]. Recent studies indicate that the diagnostic performance of the combination of CT with US is higher than that of US alone for detecting cervical LN metastasis [66 67 68]. CT may be used for the evaluation of suspicious metastatic neck LNs detected by US. CT or MRI can detect LN metastasis in the retropharyngeal or superior mediastinal compartments that may be missed by US [66]. Pre-contrast CT or MRI scans could be helpful in detecting calcified metastatic LNs or ectopic thyroid tissue [69]; however imaging studies with IV contrast injection are mandatory to assess LN metastases with strong or heterogeneous contrast enhancement as well as cystic changes [4]. A recent meta-analysis indicated that the protocol used is an important factor determining the diagnostic accuracy of neck CT and suggested that arterial phase scans and thin reconstruction slices might be helpful for improving sensitivity [70]. Neck MRI could be comparable to CT for evaluating invisible sites on US and for detecting hyperenhancing lesions after IV contrast injection. MRI has a superior soft-tissue resolution, and the gadolinium-based contrast medium does not interfere with future radioiodine administration. A recent meta-analysis reported that CT and MRI have a high pooled specificity of 87% (95% confidence interval [CI], 90–95%) and 85% (95% CI, 63–95%), respectively, for detecting metastatic LNs [70 71], although the performances of MRI

and CT were not directly compared. However, because macroscopic metastatic lesions from thyroid cancer could be small (> 3 mm), and up to 61% of LN metastases have a diameter of < 10 mm [72], conventional MRI techniques may have a lower sensitivity than CT for detecting such small metastatic LNs. Moreover, MRI might be less sensitive than CT in detecting calcified metastatic LNs. Therefore, KSThR recommends neck CT as the primary cross-sectional imaging modality for detecting LN metastasis in DTC [9].

Invasive DTC occurs in 10–15% of patients [21]. For these patients, contrast-enhanced cross-sectional imaging could be instrumental in accurately delineating the extent of aerodigestive tract invasion and vascular involvement [4 21]. MRI and CT have similar degrees of accuracy in predicting local invasion of the esophagus, trachea, and recurrent laryngeal nerve [73 74 75 76]. The scan range of CT or MRI should extend from the skull base to the superior mediastinum of the aortic arch [4 40] to accurately define the inferior border of the disease and to evaluate anatomic variations that could significantly influence surgical planning, such as an aberrant right subclavian artery [77].

Chest CT is useful for defining the inferior border of the disease and for determining the extent of mediastinal involvement in cases with significant caudal spread. In addition, it could be useful for detecting macroscopic pulmonary metastases in high-risk patients [21]. CT findings may influence patient management by indicating the need for sternotomy and/or tracheal resection/reconstruction. The administration of IV contrast is important for differentiating metastatic LNs from nonspecific mediastinal LNs, which is an important information for preoperative surgical mapping. Moreover, since the presence of lung metastasis is related to the survival rate [78 79], preoperative chest CT may be recommended before treatment only in patients with clinicopathologic risk factors [80 81].

1. Neck US is appropriate for the postoperative evaluation of DTC after definitive treatment.
2. Neck CT with IV contrast may be appropriate for early imaging after definitive treatment of DTC. It may be considered in patients with a high risk of persistent disease when the response to therapy cannot be accurately evaluated by US and serum Tg.

After thyroidectomy, the American Thyroid Association (ATA) risk stratification system is recommended to predict the risk of disease recurrence and/or persistence [21]. ATA recommends the evaluation of postoperative disease status using serum Tg measurement and neck US. Imaging studies performed in the early post-treatment period can help determine the presence of residual tumor/remnant thyroid tissue and can provide baseline information, which may be helpful for further surveillance. Moreover, early imaging studies are useful to determine the need for RAI ablation based on the results of initial risk stratification and postoperative disease status. According to the test results in the early follow-up period, the response to therapy can be classified into four categories: excellent response, biochemical response, structural incomplete response, and indeterminate response. The application of response-to-therapy assessments can affect patient management [21 82]. Five guidelines were selected for clinical situation 3. Table 8 shows the recommendation matrix of the existing guidelines for clinical situation 3.

The five selected guidelines recommend US of the thyroid bed and neck as the first-line imaging study for DTC after initial therapy in patients who undergo total thyroidectomy or lobectomy [2 9 21 23 39]. Neck US should be performed at 6–12 months after surgery to evaluate the thyroid bed and the central and lateral neck regions [21]. US is useful for detecting and characterizing abnormalities in the neck and for determining the extent of residual tumors [43 44 83 84 85 86]. US could be helpful even in the initial phases, when the Tg assay results may be difficult to interpret [41]. In the early phase (after surgery or at the time of ablation therapy), neck US should be considered in cases lacking detailed preoperative US data to detect the persistence of any LN metastases or when obvious activity is detected outside the thyroid bed on a post-ablation scan, or if pre-ablation therapy Tg values are unexpectedly high [87 88]. After lobectomy, US is the principal monitoring tool because the serum Tg level is of limited value [87 89]. After the initial US examination, periodic US scans should be performed according to the risk of recurrence and serum

Tg levels [21]. In low-risk patients, periodic US may not be necessary [90].

CT or MRI is usually not recommended as a first-line imaging tool after definitive treatment of DTC. Two of the selected guidelines mentioned the use of cross-sectional imaging as a second-line imaging modality after treatment of DTC in the following special situations [2 4 21]: 1) in patients with a high risk of persistent disease, and 2) in cases with elevated serum Tg levels or Tg antibody levels with negative findings on neck US. In these cases, CT with IV contrast injection is necessary to detect LN metastases and aerodigestive tract invasion. Although MRI may have the same role as CT in the evaluation of residual tumors, it has potential disadvantages for the detection of small enhancing lesions in the thyroid bed and other areas of the neck. Please refer to the 'Harms and benefits' for the general advantages and disadvantages of CT and MRI.

1. Neck US is usually appropriate when recurrence of DTC is suspected.
2. US-guided biopsy and/or washout Tg for neck LNs are usually appropriate when recurrence of DTC is suspected on imaging.
3. Neck CT or MRI with IV contrast may be appropriate as a second-line imaging modality in cases of widely-distributed recurrent disease, when aerodigestive tract invasion is suspected, or in cases of discrepancy between serum Tg and US results.
4. Chest CT with or without IV contrast may be appropriate in high-risk patients with elevated serum Tg or rising anti-Tg antibodies.

Recurrence of DTC may be symptomatic; however, many patients are asymptomatic and present with persistently elevated serum Tg levels or rising anti-Tg antibody levels. In these patients, neck US serves as a primary imaging tool to detect, classify, and localize potentially abnormal lesions in the neck. For any structural lesion in the neck detected by US, decisions regarding further management (active surveillance, revision surgery, local ablation therapy, or RAI) should be made according to the location of the lesion and individual clinical factors [2 21 39]. Imaging plays an important role in delineating the extent and location of the disease before additional treatment. Cross-sectional imaging of the neck and other body parts (especially the lung and mediastinum) may complement US findings when neck US fails to localize the recurrent tumor. After imaging, the response to initial therapy in these patients can be categorized as elevated serum Tg with structural disease (structural incomplete response) or elevated serum Tg with no detectable abnormality on imaging (biochemical incomplete response) [21]. Five guidelines were selected for clinical situation 4 [2 4 21 23 39]. Table 9 shows the recommendation matrix of the existing guidelines for clinical situation 4.

Five guidelines recommended neck US as the primary imaging modality for suspected recurrence of DTC [2 4 21 23 39]. US can detect and characterize recurrent tumors in the neck [43 44 83 84 85 86], and US scans should include both the thyroidectomy bed and cervical LNs [87]. US-guided biopsy should be performed to confirm malignancy in cases of suspicious or indeterminate cervical LNs (≥ 8 –10 mm; short diameter on US or CT/MRI) detected by US [9]. Biopsy should be performed if the results are necessary to determine the appropriate therapeutic intervention. The addition of FNA-Tg washout to cytology increases the sensitivity of the evaluation of cervical LNs (58–65).

Four guidelines recommended neck CT or MRI as an adjunct to US in cases of recurrent DTC. Cross-sectional imaging of the neck with IV contrast should be considered in the following cases: 1) in the setting of bulky and widely-distributed recurrent nodal disease where US may not completely delineate the extent of disease; 2) in patients with suspected recurrent disease requiring assessment of possible aerodigestive tract invasion; or 3) when neck US is inadequate for visualizing possible neck nodal disease (high Tg, negative neck US) [21]. Imaging studies should be performed with IV contrast to detect small metastatic tumors with hyperenhancement and cystic

changes. Neck CT or MRI with IV contrast complements neck US for the detection of additional metastasis in the central and lateral neck regions [68 91 92]. CT or MRI is beneficial in regions that cannot be visualized by US as well as for the assessment of invasive recurrent disease in the aerodigestive tract.

Contrast-enhanced CT of the neck is the most frequently recommended first-line cross-sectional imaging modality for detecting LN metastases. MRI is also recommended for imaging of the neck and mediastinum, and its diagnostic performance is comparable to that of CT for the detection of cervical LN metastases [71]. However, its disadvantages (refer to the 'Harms and benefits') may limit its sensitivity for the detection of small metastatic lesions. Before therapeutic intervention (revision surgery or image-guided interventions), target lesions should be accurately defined using anatomic studies, including US or cross-sectional imaging, to complement RAI imaging and to allow for adequate preoperative mapping and definitive surgical localization.

Four guidelines recommend the use of chest CT in high-risk DTC patients with elevated serum Tg (> 10 ng/mL) or rising anti-Tg antibodies with or without negative RAI imaging. Chest CT is favored because it can detect small lung metastases [21]. Although chest CT with IV contrast is preferred, chest CT without IV contrast may also be helpful for detecting lung metastases when the iodinated contrast agent is contraindicated. One guideline [21] recommended imaging of other organs, including brain MRI, MR skeletal survey, and/or CT or MRI of the abdomen in high-risk DTC patients with elevated serum Tg (> 10 ng/mL) and with negative neck and chest imaging results.

US is a sensitive method for the detection and diagnosis of thyroid nodules. There is no risk of radiation exposure, and it can evaluate changes in the thyroid parenchyma and examine LNs. Although the combination of US features can help differentiate benign from malignant thyroid nodules, some features of benign and malignant nodules overlap. This may lead to unnecessary biopsy of benign nodules, which can increase medical expenditures and complications.

The use of CT as an initial imaging test for the diagnosis of thyroid nodules is associated with a relatively high risk of radiation exposure. MRI does not have a risk of radiation exposure; however, MRI requires a longer scan time than US and CT, and it is associated with high medical costs. CT and MRI are not effective for differentiating between benign and malignant thyroid nodules. Given that CT and MRI do not have the spatial resolution to identify suspicious features on US, they should not be used as the primary imaging modality in patients with suspicious thyroid nodules.

US is the modality of choice for the preoperative and postoperative evaluation of DTC to assess ETE and cervical LN metastasis without the risk of exposure to ionizing radiation. However, US is an operator-dependent technique, and the evaluation of cervical LNs tends to be affected by the radiologist's experience. Furthermore, it is difficult to evaluate the retropharyngeal, retrosternal areas and the mediastinum using US alone [66]. CT should be considered as an adjunct to US for the detection of deeply-located or locally-invasive lesions involving the aerodigestive tract. Therefore, despite the risk of radiation exposure, CT has advantages over US when expert radiologists are not available or in cases in which invasive tumors are suspected. IV injection of iodinated contrast media during CT is necessary for the detection of LN metastasis or recurrence in the neck, which shows strong or heterogeneous enhancement. The iodinated contrast media used in contrast-enhanced CT may delay RAI therapy because it alters RAI uptake for months [93]. However, the use of iodinated contrast media is not contraindicated for DTC, as suggested by recent data on iodine retention [4 9 21]. These studies demonstrated that delayed RAI therapy is not necessary for patients who undergo preoperative contrast-enhanced CT and that the iodine content of the body is not an important determinant of thyroid ablation [94 95 96]. CT scans without IV contrast may be useful for detecting metastatic LNs with macrocalcifications or ectopic thyroid tissues; however, its value as an isolated imaging study has not been investigated. Therefore, a protocol including both pre- and post-contrast scans is preferred for evaluating LN metastases in patients with DTC.

MRI of the neck and mediastinum has the same role as CT for evaluating sites with limited detection on US. It provides superior soft-tissue contrast and does not require the injection of iodinated contrast media. However, MRI has disadvantages such as a longer scan time and possible motion artifacts in the lower neck associated with respiration or swallowing, and it is less sensitive than CT for the detection of small cervical LNs or small lung nodules because of its lower spatial resolution. Recent advances in MR image quality and faster MRI acquisition may overcome these limitations; however, these advances remain to be implemented in patients with DTC. Lastly, MRI is associated with more medical expenditure.

Currently, US, CT, and MRI are available in most hospitals in Korea. An evaluation of domestic acceptability and the applicability of guidelines indicated that neck US, CT, and MRI could be used for the evaluation of thyroid nodules and for the pre- and postoperative evaluation of DTC. The cost of preoperative US, CT, and MRI might be reasonable because the individual becomes eligible for insurance coverage in cases in which thyroid cancer is diagnosed through biopsy in South Korea.

The summary of recommendations and evidence levels are described in Table 10 .

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Author Contributions: Conceptualization: Ji Ye Lee, Jung Hwan Baek.

Funding acquisition: Jung Hwan Baek, Korean Society of Thyroid Radiology (KSThR) and Korean Society of Radiology.

Investigation: Ji Ye Lee, Jung Hwan Baek, Miyoung Choi.

Methodology: Jung Hwan Baek, Eun Ju Ha, Miyoung Choi, Ji Ye Lee.

Resources: Ji Ye Lee, Jung Hwan Baek, Eun Ju Ha, Miyoung Choi, Dong Gyu Na.

Validation: Ji Ye Lee, Jung Hwan Baek, Dong Gyu Na.

Writing—original draft: Ji Ye Lee, Jung Hwan Baek.

Writing—review & editing: Ji Ye Lee, Jung Hwan Baek, Eun Ju Ha, Jin Yong Sung, Jung Hee Shin, Ji-hoon Kim, Min Kyoung Lee, So Lyung Jung, Young Hen Lee, Hye Shin Ahn, Jung Hyun Yoon, Yoon Jung Choi, Jeong Seon Park, Yoo Jin Lee, Dong Gyu Na.

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Relative radiation levels in Korean clinical imaging

CT = computed tomography, MRI = magnetic resonance imaging, US = ultrasonography

AACE/AME/ETA = American Association of Clinical Endocrinologists/Italian Association of Clinical Endocrinologists/European Thyroid Association, ACR = American College of Radiology, CT = computed tomography, FNA = fine-needle aspiration, IV = intravenous, MRI = magnetic resonance imaging, NCCN = National Comprehensive Cancer Network, US = ultrasonography

AACE/AME/ETA = American Association of Clinical Endocrinologists/Italian Association of Clinical Endocrinologists/European Thyroid Association, ACR = American College of Radiology, CT = computed tomography, FNA = fine-needle aspiration, FNAC = FNA cytology, IV = intravenous, MRI = magnetic resonance imaging, NCCN = National Comprehensive Cancer Network, PET = positron emission tomography, Tg = thyroglobulin, US = ultrasonography, 18 FDG = 18-fluorodeoxyglucose

ACR = American College of Radiology, CT = computed tomography, DTC = differentiated thyroid carcinoma, IV = intravenous, MRI = magnetic resonance imaging, NCCN = National Comprehensive Cancer Network, RRA = radioiodine remnant ablation, Tg = thyroglobulin, TSH = Thyroid stimulating Hormone, US = ultrasonography, WBS = whole body scan

ACR = American College of Radiology, CT = computed tomography, DTC = differentiated thyroid carcinoma, IV = intravenous, MRI = magnetic resonance imaging, NCCN = National Comprehensive Cancer Network, PET = positron emission tomography, RAI = radioactive Iodine, rhTSH = recombinant human thyrotropin, Tg = thyroglobulin, TSH = Thyroid stimulating Hormone, US = ultrasonography

CT = computed tomography, DTC = differentiated thyroid carcinoma, IV = intravenous, MRI = magnetic resonance imaging, RRL = relative radiation level, Tg = thyroglobulin, US = ultrasonography